CLAIMS

I claim:

1. A method for processing data to provide a forewarning of a critical event, comprising:

acquiring a plurality of sets of data for at least one channel of data for at least one test subject or process;

computing a renormalized measure of dissimilarity from distribution functions derived from a phase space for each respective channel of data;

comparing said renormalized measure of dissimilarity to a threshold (U_C) for a number of occurrences (N_{OCC}) to indicate a condition change in said renormalized measure of dissimilarity;

detecting a simultaneous condition change in a plurality (N_{SIM}) of renormalized measures of dissimilarity to determine a forewarning of the critical event; and

wherein said one channel of data corresponds to a parameter that is calculated from a plurality of parameters corresponding to a plurality of channels of data.

2. The method of claim 1, wherein the test subject is a human patient.

3. The method of claim 1, wherein the test subject is a mechanical device or physical process.

4. The method of claim 1, wherein the process-indicative data is three-phase electrical power.

5. The method of claim 1, wherein the process-indicative data is vibration mechanical power.

6. The method of claim 1, wherein the process-indicative data is a difference between two channels of EEG data.

7. The method of claim 1, further comprising:

performing a first filtering of each set of data with a zero-phase quadratic filter that filters out high-frequency artifacts; and

performing a second filtering of each set of data with a zero-phase quadratic filter to filter out low-frequency artifacts.

8. The method of claim 1, further comprising:

sorting the data values into ascending order from a minimum to a maximum;

determining the number of unique signal values (n) and the corresponding relative occurrence frequency (F_k) for each unique signal value (v_k);

displaying a graph of frequency (F_k) versus values (v_k) in each bin in a connected phase space; and

discarding data that has $[v_k - (N/n)]/\sigma_3 > z$, where the value of z is determined by solving $1/n = ½ \operatorname{erfc}(z/\sqrt{2})$, and σ_3 is the standard deviation in the occurrence frequency.

9. The method of claim 1, with an alternative embodiment for event forewarning, comprising determining a sequence of renormalized phase space dissimilarity measures from data sets for the test subject or process; summing said renormalized measures into a composite measure, C_i, for the i-th data set; performing a least-squares analysis over a window of m points of the said composite measure to obtain a straight line, $y_i=ai+b$, that best fits said composite data in a least-squares sense; determining the variance, $\sigma_1^2 = \Sigma_i (y_i - C_i)^2/(m-1)$, of said composite measure with respect to the straight line fit; obtaining the variability of the sequel window of m sequential points via the statistic, $G = \Sigma_i (y_i - C_i)^2/\sigma_1^2$; comparing said value of G to the running maximum value of the same statistic, G_{max}; determining the forewarning of or failure onset of a

critical event (such as a machine failure), when G is significantly more than G_{max}; obtaining the ratio, $R = (G_{max})_k/(G_{max})_{k-1}$, of the present and previous running maximum in G; and determining the forewarning of a critical event when R is significantly more than some limit.

10. A method for processing data to provide a forewarning of a critical event, comprising:

acquiring a plurality of sets of data for at least two channels of data for at least one test subject or process;

computing to a multi-channel time-delay phase-space (PS) construction, which has the form: $y(i) = [s(1)_i, s(1)_{i+\lambda}, s(1)_{i+2\lambda}, \ldots, s(2), s(2)_{i+\lambda}, s(2)_{i+2\lambda}, \ldots, s(c)_i, s(c)_{i+\lambda}, s(c)_{i+2\lambda}, \ldots]$, where $s(c)$ denotes the symbolized data for c-th channel;

computing a renormalized measure of dissimilarity from distribution functions derived from the (non)connected phase space for the multi-channel of data;

comparing said renormalized measure of dissimilarity to a threshold (U_C) for a number of occurrences (N_{OCC}) to indicate a condition change in said renormalized measure of dissimilarity; and

detecting a simultaneous condition change in a plurality (N_{SIM}) of renormalized measures of dissimilarity to determine a forewarning of the critical event.

11. The method of claim 10, further comprising:

performing a first filtering of each set of data with a zero-phase quadratic filter that filters out high-frequency artifacts; and

performing a second filtering of each set of data with a zero-phase quadratic filter to filter out low-frequency artifacts.

12. The method of claim 10, using an alternative embodiment for event forewarning, comprising determining a sequence of renormalized phase space dissimilarity measures from data sets collected during increasingly severe fault

conditions; summing said renormalized measures into a composite measure, C_i, for the i-th data set; performing a least-squares analysis over a window of m points of the said composite measure to obtain a straight line, $y_i=ai+b$, that best fits said composite data in a least-squares sense; determining the variance, $\sigma_1^2 = \Sigma_i (y_i - C_i)^2/(m-1)$, of said composite measure with respect to the straight line fit; obtaining the variability of a sequel window of m sequential points via the statistic, $G = \Sigma_i (y_i - C_i)^2/\sigma_1^2$; comparing said value of G to the running maximum value of the same statistic, G_{max}; and determining the onset of a critical event, such as forewarning of a machine failure, when G is significantly more than G(non-end-of-life), or when R is significantly more than R(non-end-of-life), or detection of failure onset when G is significantly greater than G(end-of-life).

13. The method of claim 10, wherein the test subject is a human patient.

14. The method of claim 10, wherein the test subject is a mechanical device or physical process.

15. The method of claim 10, further comprising:

sorting the data values into ascending order from a minimum to a maximum;

determining the number of unique signal values (n) and the corresponding relative occurrence frequency (F_k) for each unique signal value (v_k);

displaying a graph of frequency (F_k) versus values (v_k) in each bin in a connected phase space; and

discarding data that has $[v_k - (N/n)]/\sigma_3 > z$, where the value of z is determined by solving $1/n = ½ \operatorname{erfc}(z/\sqrt{2})$, and σ_3 is the standard deviation in the occurrence frequency.

16. The method of claim 10, wherein the process-indicative data is three-phase electrical power.

17. The method of claim 1, wherein the process-indicative data is vibration mechanical power.

18. The method of claim 1, wherein the process-indicative data is a difference between two channels of EEG data.